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ORIENTATION, SURROGATE TRAVEL, AND GENDER DIFFERENCES IN VIDEOGAME STRATEGY

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This research note examines the information processing components of a videogame called MAZE, in order to determine if males and females differ in the basic cognitive skills required by the game. While videogame performance was similar for males and females, the cognitive components underlying game performance were not the same. Since individuals who seemingly use different cognitive skills show similar levels of game performance, different strategies apparently may be employed to achieve the same results. Future instructional paradigms

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should provide for flexibility in strategy development, so that learners may make the best use of their individual cognitive strengths.

ORIENTATION, SURROGATE TRAVEL, AND GENDER DIFFERENCES IN VIDEOGAME STRATEGY

EXECUTIVE SUMMARY

Requirement:

To examine information processing components in a videogame entitled MAZE to determine if males and females differ in the basic cognitive skills required by the game.

Procedure:

Subjects played a series of eight videogames in which they had to escape from a 5 x 5 x 5 cubic maze. They also completed several psychometric tests as well as the Bem Sex-Role Inventory. Players moved through the 125-room maze by hitting a key indicating direction (e.g., "N" for north, "U" for up, etc.). Several performance measures were derived for each game including SCORE (the time to complete one game), STATIONARY TIME (average time between keypresses), and EFFICIENCY (ratio of the minimum distance to escape and the actual number of rooms visited).

Findings:

Results of this experiment indicated little variation in game performance attributable to gender. In contrast, regression analyses indicated that the cognitive components underlying game performance differ for males and females.

Utilization of Findings:

These findings suggest gender-related strategy differences. One implication of these findings is that future instructional paradigms should provide for flexibility in strategy development so that learners may make the best of their individual cognitive strengths.

ORIENTATION, SURROGATE TRAVEL, AND GENDER DIFFERENCES IN VIDEOGAME STRATEGY

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Spatial skills, sometimes referred to as nonverbal skills, are those that are involved in processing spatial information. Some examples of spatial information are patterns, two-dimensional drawings that portray three-dimensional figures, or maps. Spatial ability is critical to reading maps, orienting yourself, navigating through space, or knowing your right from your left.

Research has shown that individuals vary a great deal in how they process and use spatial information. They differ in how they mentally encode and represent spatial information, how they manipulate that information in memory, and the procedures or strategies they use to navigate in their immediate environment (Kosslyn, Brunn, Cave, & Wallach, 1983). Thorndyke and Goldin (1983) have shown that superiority on complex spatial tasks derives from individual differences in these basic cognitive abilities. They have demonstrated that people who are good at interpreting or drawing maps performed significantly better on paper and pencil tests that assess ability to process spatial information.

Individuals also differ in the frame of reference they use to form memory representations of space (Sholl & Egeth, 1980). Some use an egocentric system, characterized by directional terms (e.g., right or left) whereas others use a topographic system, characterized by cardinal directions (e.g., north or south). Developmental studies (Pick & Reiser, 1982) have suggested that individuals adopt the topographic, more sophisticated system as they mature.

Piaget has suggested that physical movement through the environment is how spatial reasoning skills are acquired. Goldin and Thorndyke (1981) support Piaget's arguments, demonstrating that navigation through space provides a unique kind of spatial knowledge, called procedural knowledge, that cannot be acquired simply by reading maps. Procedural knowledge is the information in memory you would use to travel from one place to another. In contrast, survey knowledge, the knowledge of two-dimensional relationships among locations and routes, can be acquired either through map reading or extensive navigation experience.

The fact that movement leads to procedural knowledge acquisition has been applied to navigation training. Cohen (1980) has shown that the information derived from actually traveling through space can be approximated by surrogate travel. In some cases, simulated movement may be even more effective as a training aid than actual navigation, because the relevance of the information can be controlled; if only relevant information is presented, then irrelevant information cannot be distracting.

Another area of individual differences focuses on gender and related variables. Much research (Wittig & Petersen, 1979; Tkacz, 1981) has demonstrated gender differences in spatial information processing ability, including the relationship of these cognitive variables to sex-role identity. Since previous research has shown that individuals tend to conform to sex-role expectations, and expertise in computers and videogames is considered masculine, it is reasonable to predict that females may not perform as well as males. Whether lower female performance is due to a lack of cognitive ability or adherence to sex-role expectations has not been established.

The research described below investigated the way people navigate through an artificial environment created by a microcomputer. In particular, the game required players to use a topographic reference system to indicate directions. In addition to several dependent measures derived from the videogame, cognitive ability components assumed to underly game performance were assessed. These cognitive components were also examined to see if females and males differ in the basic cognitive skills required by the game.

Method

One hundred and ninety undergraduates served as participants, for which they received extra credit in their introductory psychology class. They were administered several psychometric tests including figural reasoning (Figure 1), abstract orientation (Figure 2), map orientation (Figure 3), mental rotation (Figure 4), and vocabulary. They also played a series of eight videogames in which they were required to escape from a maze.

The maze was a 5 x 5 x 5 cube. The object of the game was to escape through a secret door that was on the surface of the cube. The player moved from one room to the next through openings in the floors, walls, and ceilings of the 125 room structure. They were provided with a "map" to help them visualize what the cube would look like (Figure 5). To indicate the direction they wished to travel, the player typed "n", "s", "e", "w", "u", or "d" for north, south, east, west, up or down directions.

One between-subjects variable was INFORMATION CONDITION, which describes the information available to the players. The two types of information were current Position (P) and location of the escape room or Goal (G), each defined by x, y, z coordinates. All possible combinations of these two types of information formed the four INFORMATION CONDITIONS: PG, P, G, or Q.

In the PG condition, information on both the player's Position (P) in the maze and the location of the Goal (G) was provided continuously on the screen. In the P condition, information was provided only about the current Position. Participants in the G condition had information only about the Goal room. Those in the Q condition had no information displayed on the screen, but were permitted to request both P and G coordinates. Finally, all subjects could change their orientation at any time. Figure 6 shows what a typical screen might look like in the PG condition.

All participants played four PG games in the first session, in order to familiarize them with the game and the keyboard. The second session consisted of four more games, in one of the four INFORMATION

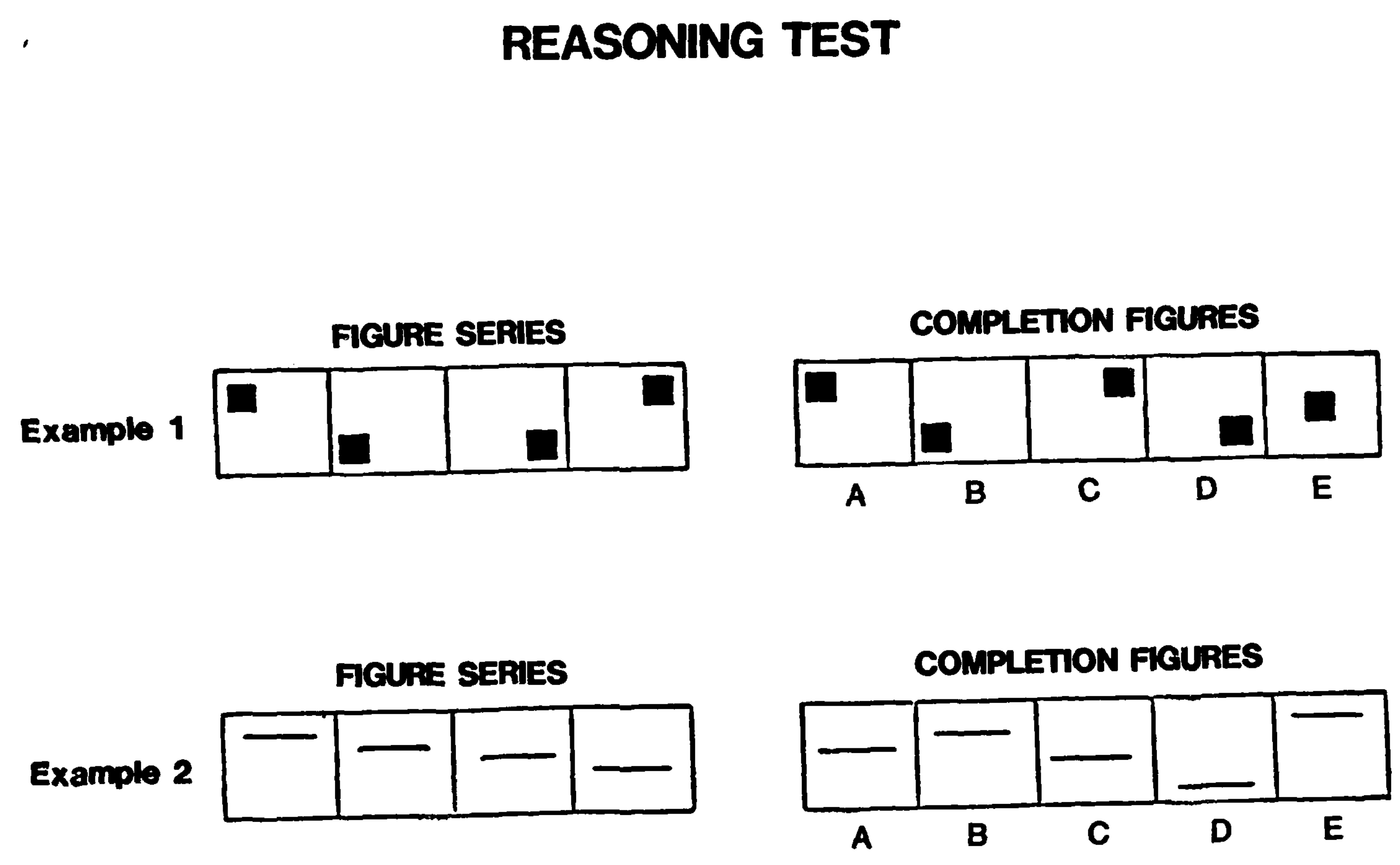


Figure 1. Sample item from Reasoning Test.

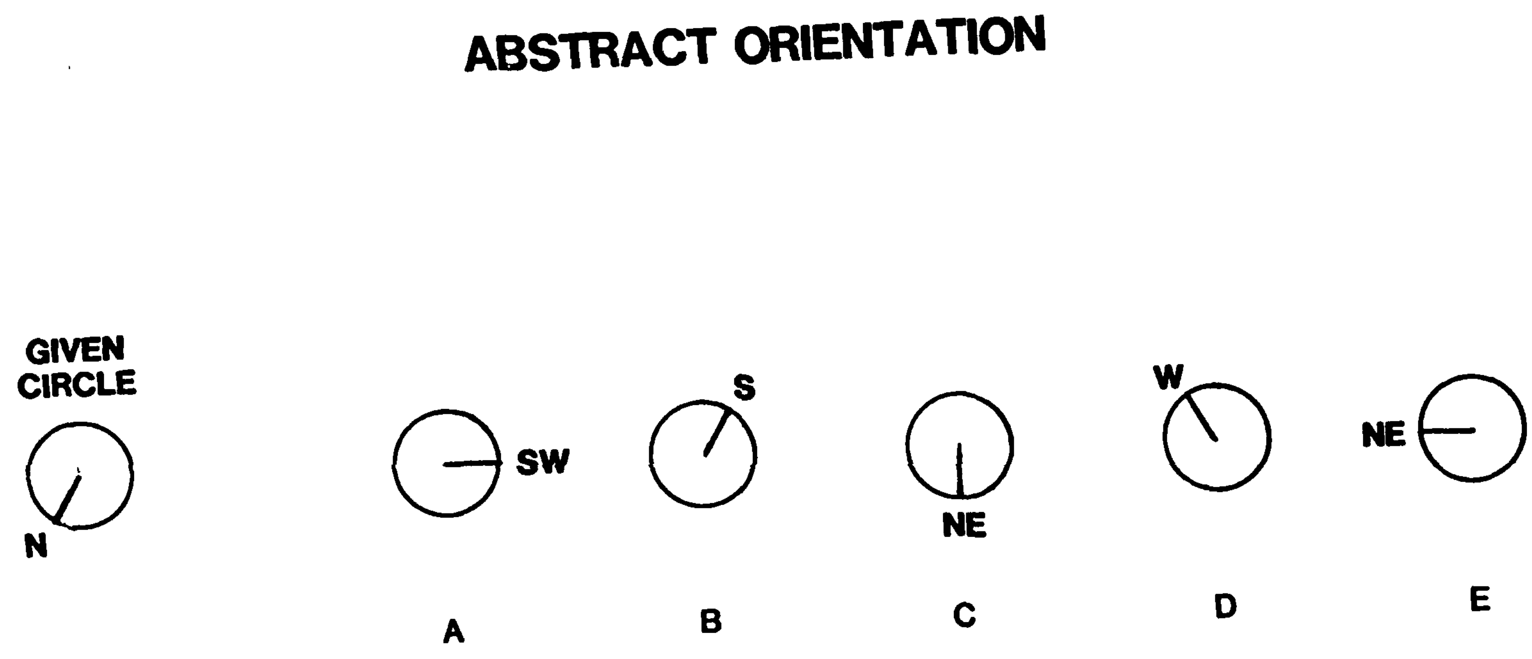
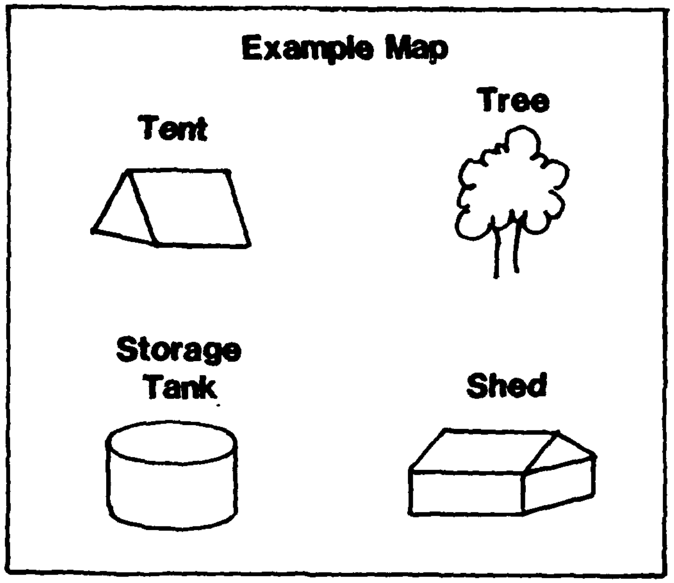


Figure 2. Sample item from Abstract Orientation Test.

MAP ORIENTATION



1. The shed is due north of the tree. You are at the storage tank. Which direction must you travel to reach the tent?

   1. N 2. NE 3. E 4. SE 5. S 6. SW 7. W 8. NW

2. The tent is due west of the storage tank. You are at the storage tank. Which direction must you travel to reach the tree?

   1. N 2. NE 3. E 4. SE 5. S 6. SW 7. W 8. NW

Figure 3. Sample Item from Map Orientation Test.

MENTAL ROTATIONS TEST

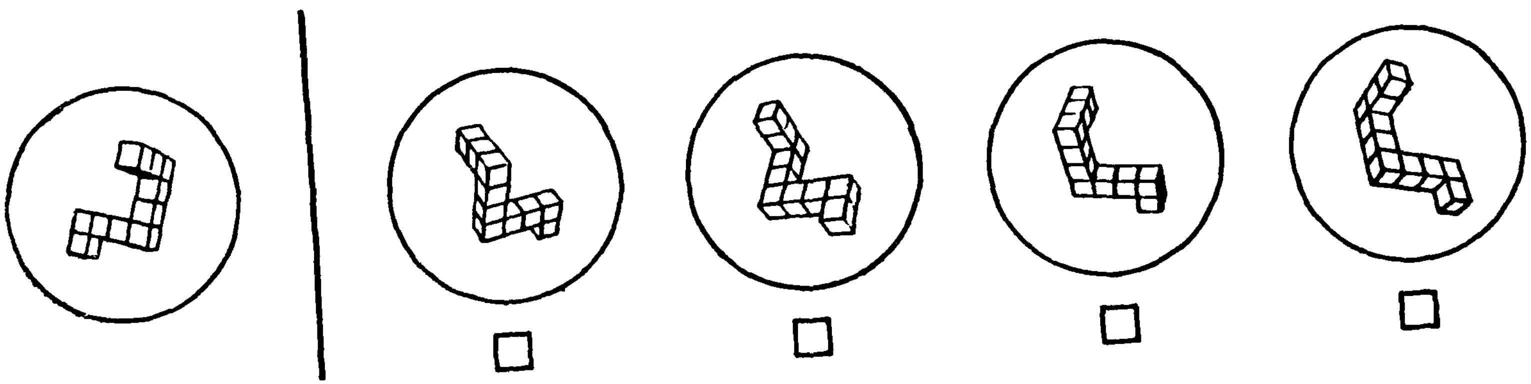


Figure 4. Sample item from Mental Rotations Test.

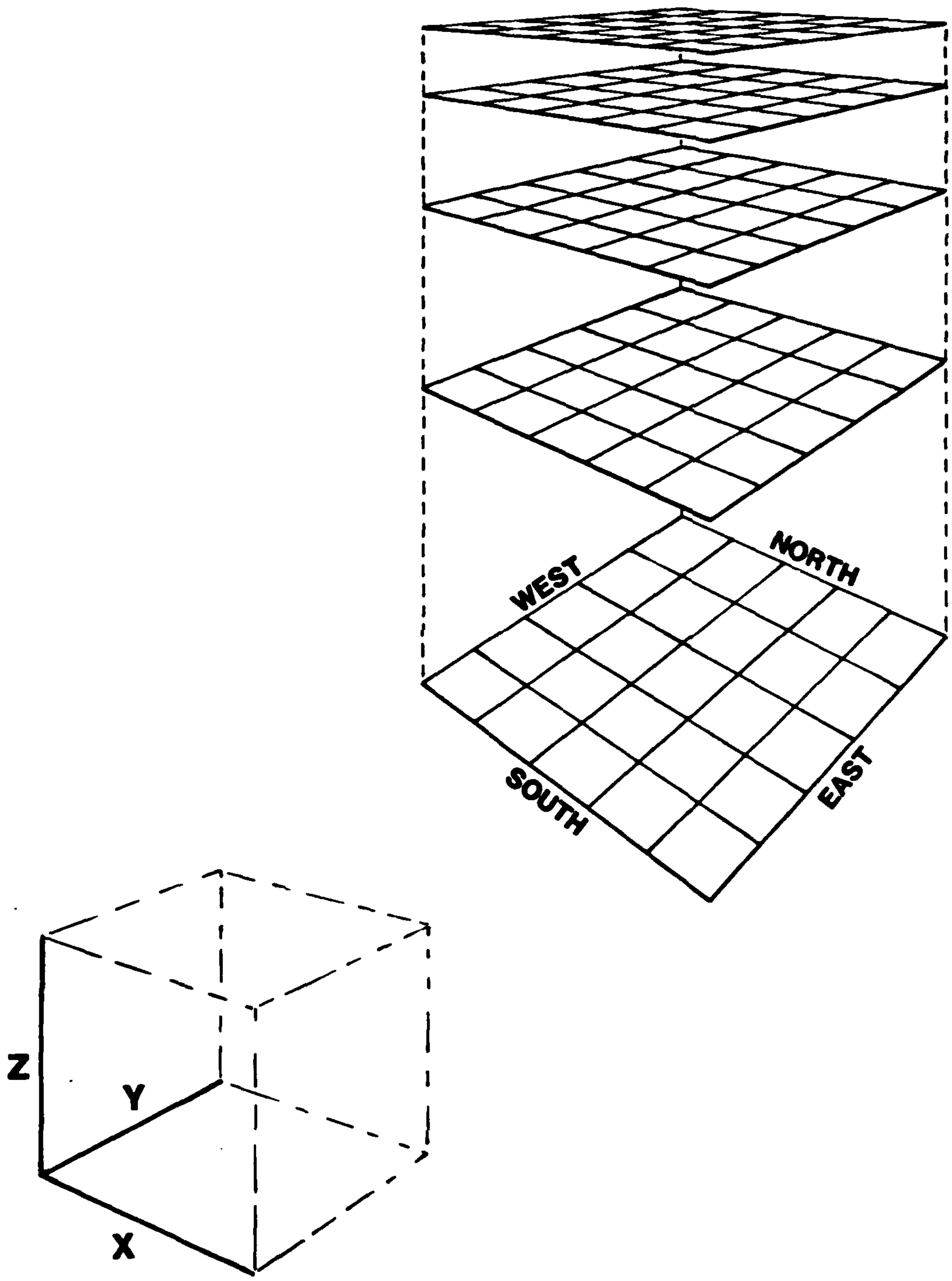


Figure 5. Map of game space.

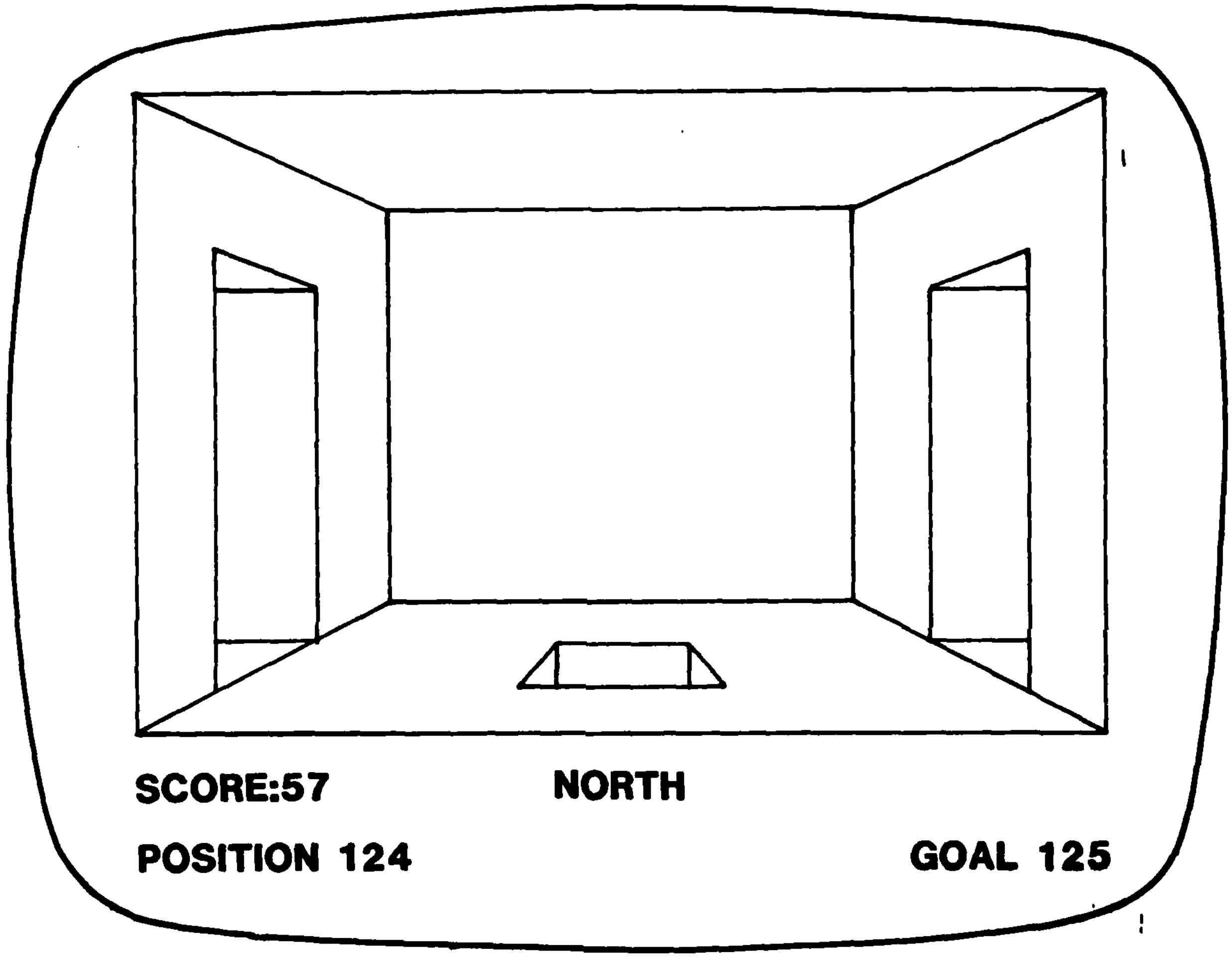


Figure 6. Visual screen display.

CONDITIONS.

Results and Discussion

As expected, male performance was superior for all three spatial tests. Table 1 shows means for males and females for all psychometric tests. There were no gender differences on vocabulary or reasoning tests. These data indicate that males and females differ significantly in the skills they bring to the experiment that were expected to underly game performance.

Game performance was described by ten dependent variables derived from individual key presses for each game. SCORE indicates the total time to complete one game. RESPONSE TIME indicates the mean time between any two keypresses. Similarly, STATIONARY TIME indicates mean time spent in a room. This was calculated by considering only "n", "s", "e", "w", "u", or "d" keypresses, and disregarding all other keypresses such as requests for information. EFFICIENCY is a ratio of the minimum distance to actual distance between starting Position and Goal room. REORIENTATION is the rate (the number of times per minute) that players changed the direction they were facing. SURFACE RATE is a measure of the time spent in surface rooms of the cube. Similarly, INTERIOR RATE is a measure of the time spent in interior rooms of the cube. VISIBLE CRASH indicates how many times a player tried to go through a wall, visible on the screen, that did not have a door. Similarly, REAR CRASH indicates how many times a player tried to go through the wall behind them, and therefore not visible on the screen. Lastly, ERROR KEY is a measure of how many illegitimate keys were pressed.

A 2 x 2 x 4 analysis of variance was performed on the ten dependent measures with two between-subjects variables (INFORMATION CONDITION, C and GENDER, G) and one within-subjects variable (PRACTICE, P). Significant results are presented in Table 2. SCORE and REORIENTATION were the only dependent measures for which any GENDER (G) effect was obtained. Although almost all measures improved with PRACTICE (P), the GENDER x PRACTICE interaction (GP) was significant only for SCORE, suggesting that, while their initial scores may be lower, females may show greater improvement. The effect of INFORMATION CONDITION (C) was significant for all variables except RESPONSE TIME and REORIENTATION, indicating that the rate of key pressing and the rate of turning is independent of the amount and type of information available. Finally, a PRACTICE x INFORMATION CONDITION interaction (CP) was obtained for several measures - SCORE, STATIONARY TIME, SURFACE RATE, INTERIOR RATE, REAR CRASH, and ERROR KEY.

Table 1. Gender differences in psychometric measures.

Variable	Female Mean	Male Mean	t	p
Abstract Orientation	101	113	3.4	.001
Map Orientation	8.5	10.2	2.7	.01
Figural Reasoning	22.6	22.4	.2	*
Mental Rotation	25.6	27.7	2.2	.05
Vocabulary	55.3	55.2	0	*

Table 2. Analyses of variance on ten videogame measures.

Dependent measure	Source of variation	F	p
Score	C	76.3	.001
	G	11.6	.001
	P	15.3	.001
	CP	3.0	.001
	GP	2.9	.05
Response time	P	55.3	.001
Stationary time	C	18.1	.001
	P	30.0	.001
	CP	3.7	.001
Efficiency	C	64.8	.001
	P	2.9	.05
Reorientation	G	7.1	.01
Surface rate	C	6.7	.001
	P	40.9	.001
	CP	2.7	.01
Interior rate	C	27.2	.001
	CP	1.9	.05
Visible crash	C	11.6	.001
	P	9.6	.001
	G	4.1	.05
Rear crash	C	51.3	.001
	P	8.5	.001
	CP	5.1	.001
Error key	C	9.2	.001
	P	3.8	.01
	CP	2.5	.01

The fact that this interaction was not obtained for all dependent variables indicates that improvement in performance is not simply a function of repeated practice. These game-derived performance measures may be indices of individual differences in information-processing capacity, and not subject to practice effects. Means for these dependent measures are shown in Table 3. Here, SCORE and REAR CRASH were the only variables for which any gender difference was obtained. Further, male superiority on these dependent measures occurred in only two INFORMATION CONDITIONS, G and Q. These results suggest that performance is very similar for males and females.

Data in Table 2 also indicate that performance varies across INFORMATION CONDITION (C) for every variable except RESPONSE TIME. These data are presented graphically for each of the ten dependent measures. Figure 7 presents SCORE for four PG games, for all 190 subjects, demonstrating rapid improvement (all other figures refer to data for the last four games only). Figure 8 shows SCORE after subjects were divided into the four INFORMATION CONDITION groups. For the PG group, whose last four games are also PG games, performance has obviously stabilized. Research reported by Jones (1984) and others suggests that this stability in performance will be maintained over as long as 18 months. For the other three groups, who were assigned to different INFORMATION CONDITIONS for these last four games, performance still improves rapidly. It is also evident from Figure 8 that the INFORMATION CONDITIONS differ significantly in difficulty level.

Figure 9 shows that players in the Q group were as efficient as the PG subjects, indicating that they requested and used information pertinent to their task. Further analyses on Q data are being performed to describe the kind and the rate of information requests.

The measures shown in Figures 10 and 11 are kinds of "speed of processing" measures. They refer to the number of seconds between keypresses. RESPONSE TIME includes all keypresses, while STATIONARY TIME includes only key presses that actually move the player into an adjacent room. It is interesting to note that there is no INFORMATION CONDITION effect for RESPONSE TIME, indicating that the key press rate is independent of both the kind and amount of information available. The elevated function in the Q condition (see Figure 11) indicates only that subjects stood still and asked questions before moving.

Figures 12, 13, and 14 depict variables that are more strategy-related than those discussed above, describing decision making more than information processing. REORIENTATION, the number of times per minute that a player changes the direction s/he faces, is much higher for males than females. Figure 12 illustrates male (top function), female (bottom function), and mean performance. Assuming that INFORMATION CONDITIONS increase in difficulty (from left to right), male REORIENTATION RATE approaches female performance as the games become more difficult. CRASH RATE data is presented in Figure 13. Visible crashes occur more frequently, which is not suprising since the ratio of visible to rear surfaces is five to one. However, a very high REAR CRASH rate is obtained for the most difficult condition, P. Taken together with REORIENTATION RATE, these data

Table 3. Results of t-tests on videogame measures.

Variable	INFORMATION CONDITION	Female Mean	Male Mean	t	p
Score	PG	82	61	1.197	*
	Q	142	99	1.656	*
	G	414	247	3.073	.01
	P	639	507	1.493	*
Response time	PG	4.4	4.0	.608	*
	Q	3.8	3.7	.182	*
	G	3.5	3.8	.651	*
	P	3.7	3.3	.987	*
Stationary time	PG	5.5	5.1	.457	*
	Q	9.8	8.8	.618	*
	G	4.7	4.8	.170	*
	P	5.2	4.6	1.075	*
Efficiency	PG	.60	.59	.212	*
	Q	.56	.63	1.246	*
	G	.21	.21	0	*
	P	.11	.11	0	*
Reorientation	PG	.07	1.16	1.726	*
	Q	.09	.47	1.212	*
	G	.10	.31	1.243	*
	P	.09	.20	.808	*
Surface rate	PG	8.28	8.52	.213	*
	Q	5.95	5.42	.581	*
	G	6.45	6.90	.623	*
	P	7.07	8.83	1.872	*
Interior rate	PG	3.59	3.68	.127	*
	Q	1.65	2.26	1.954	*
	G	1.33	1.72	1.047	*
	P	1.01	1.05	.119	*
Visible crash	PG	1.72	1.49	.572	*
	Q	.85	.88	.103	*
	G	3.84	2.38	1.692	*
	P	3.02	2.10	1.530	*
Rear crash	PG	.69	.70	.037	*
	Q	.48	.21	2.808	.01
	G	1.36	1.28	.293	*
	P	2.38	2.47	.224	*
Error key	PG	.11	.20	.976	*
	Q	.40	.52	.661	*
	G	.08	.12	.679	*
	P	.13	.22	.584	*

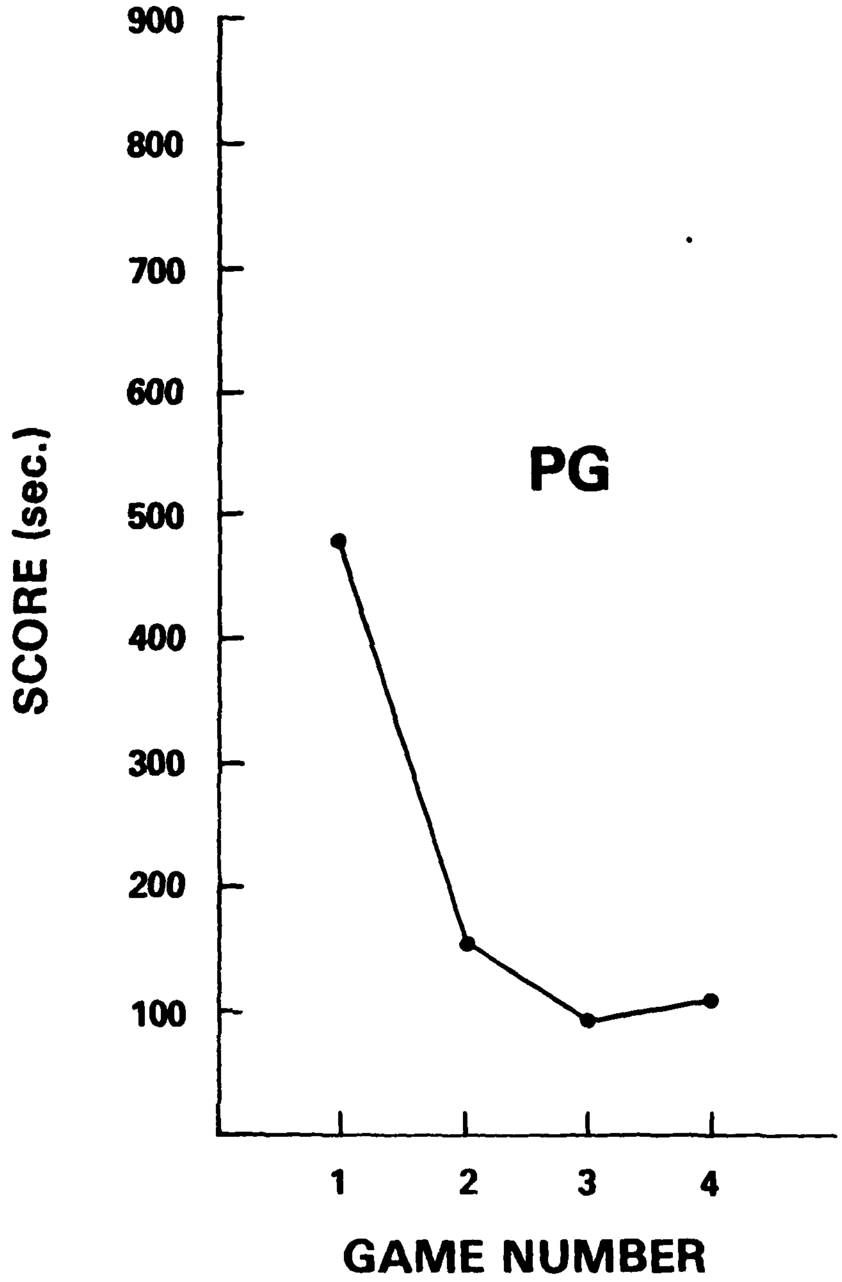


Figure 7. SCORE for first four games.

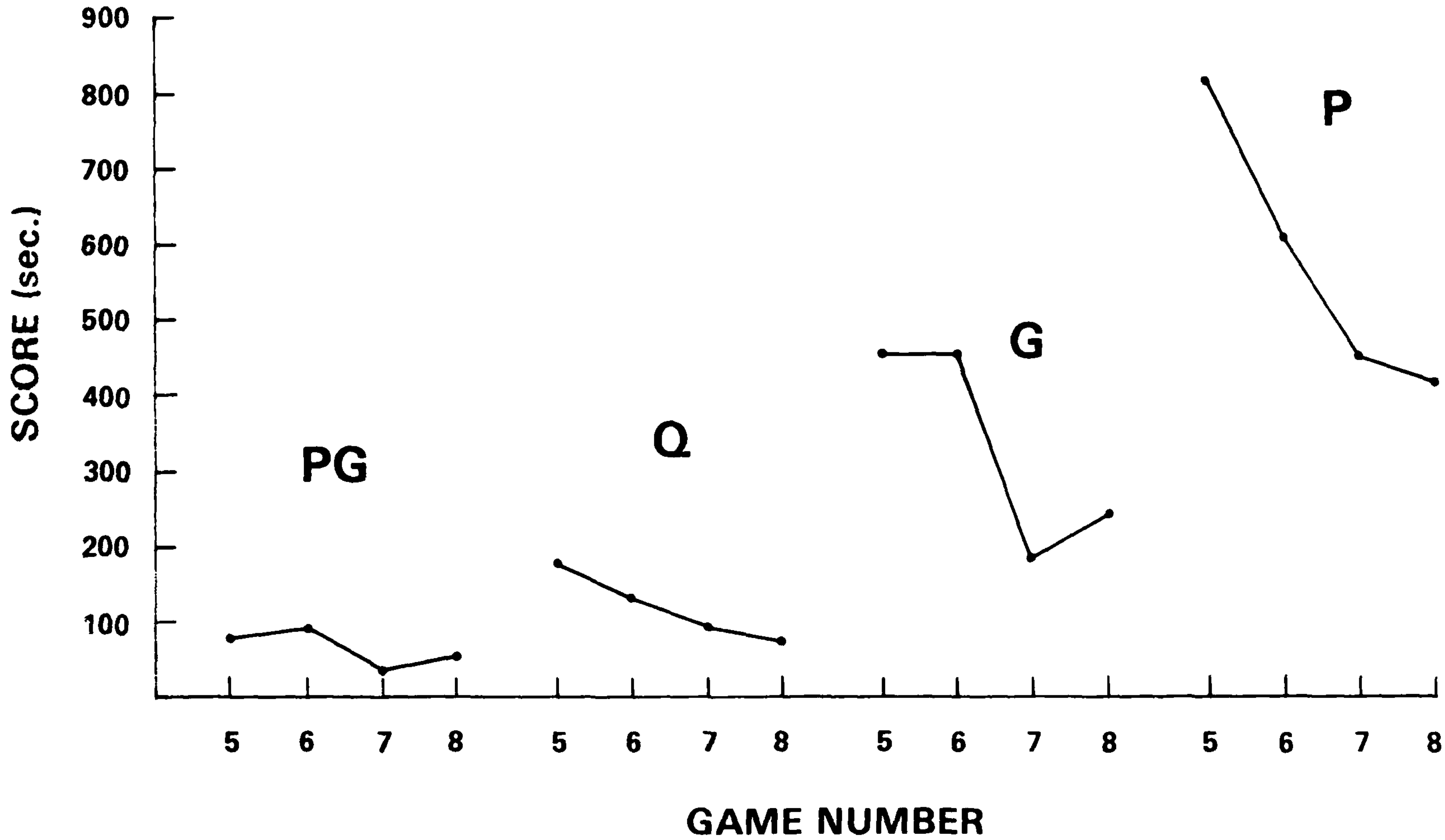


Figure 8. SCORE for last four games, for each Condition.

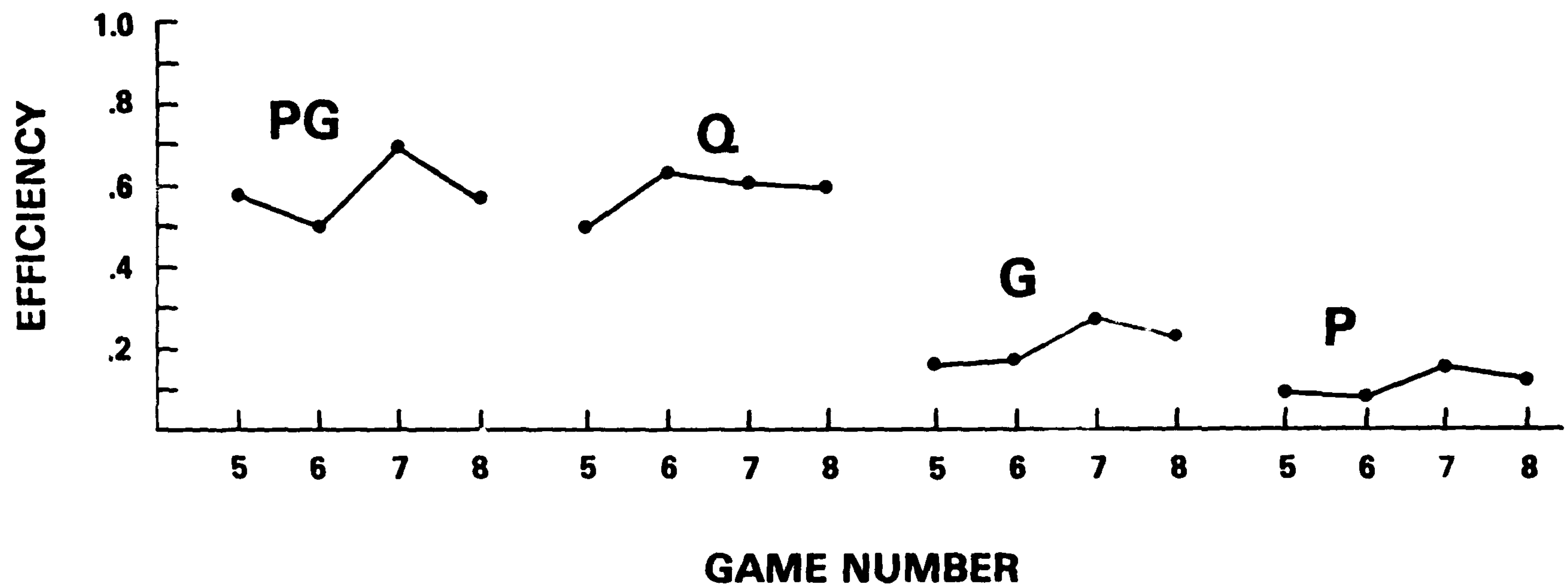


Figure 9. EFFICIENCY for each Condition.

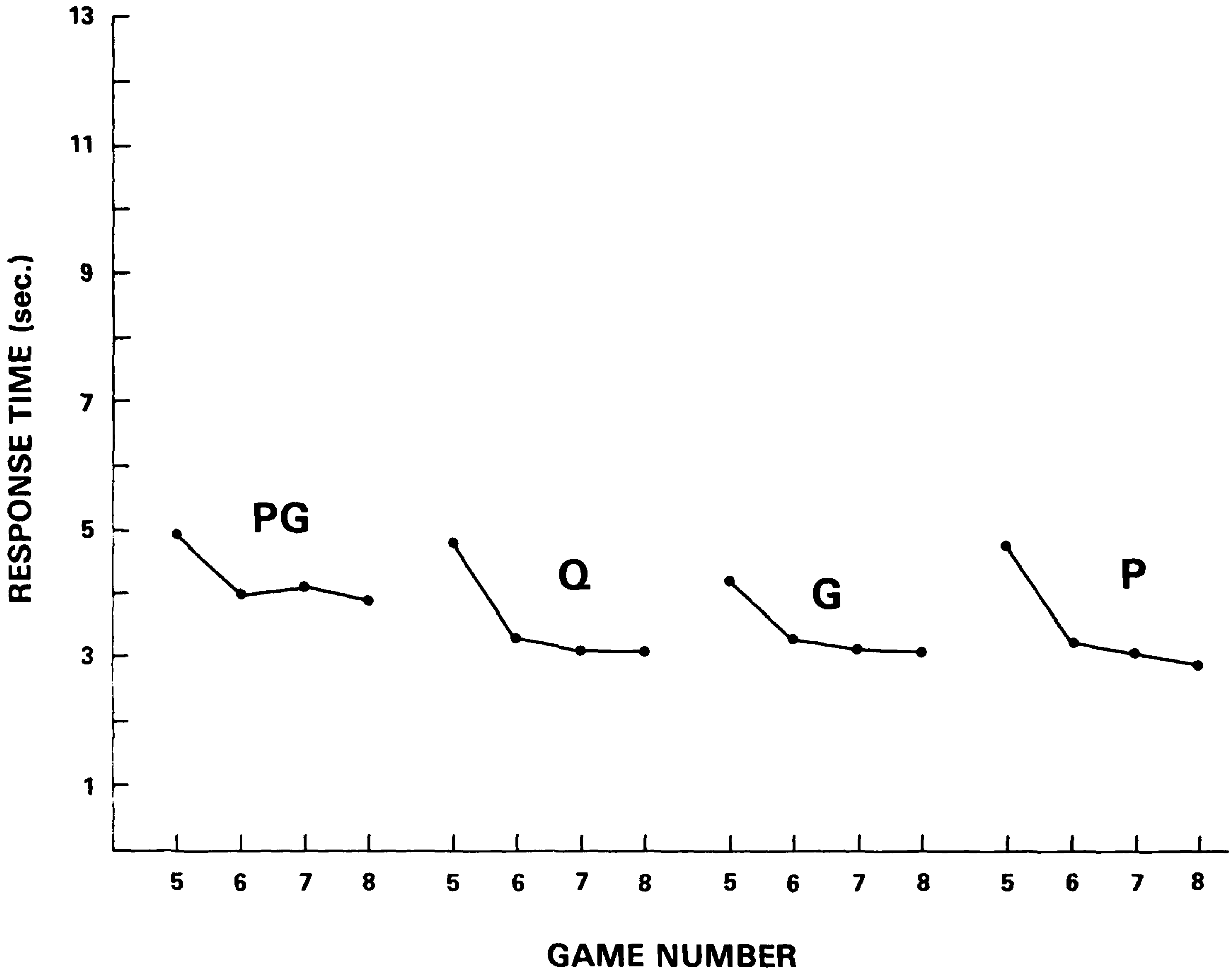


Figure 10. RESPONSE TIME for each Condition.

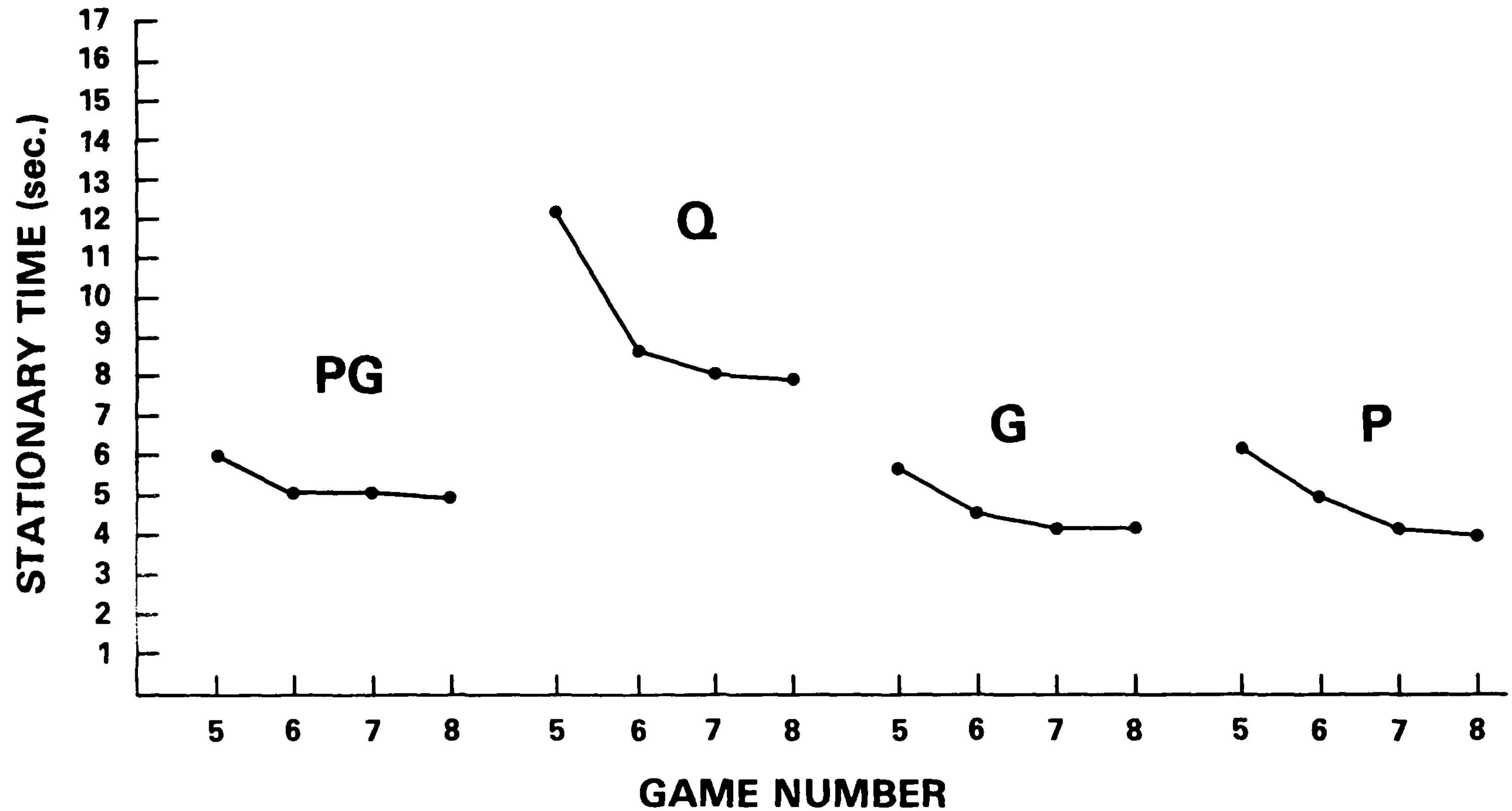


Figure 11. STATIONARY TIME for each Condition.

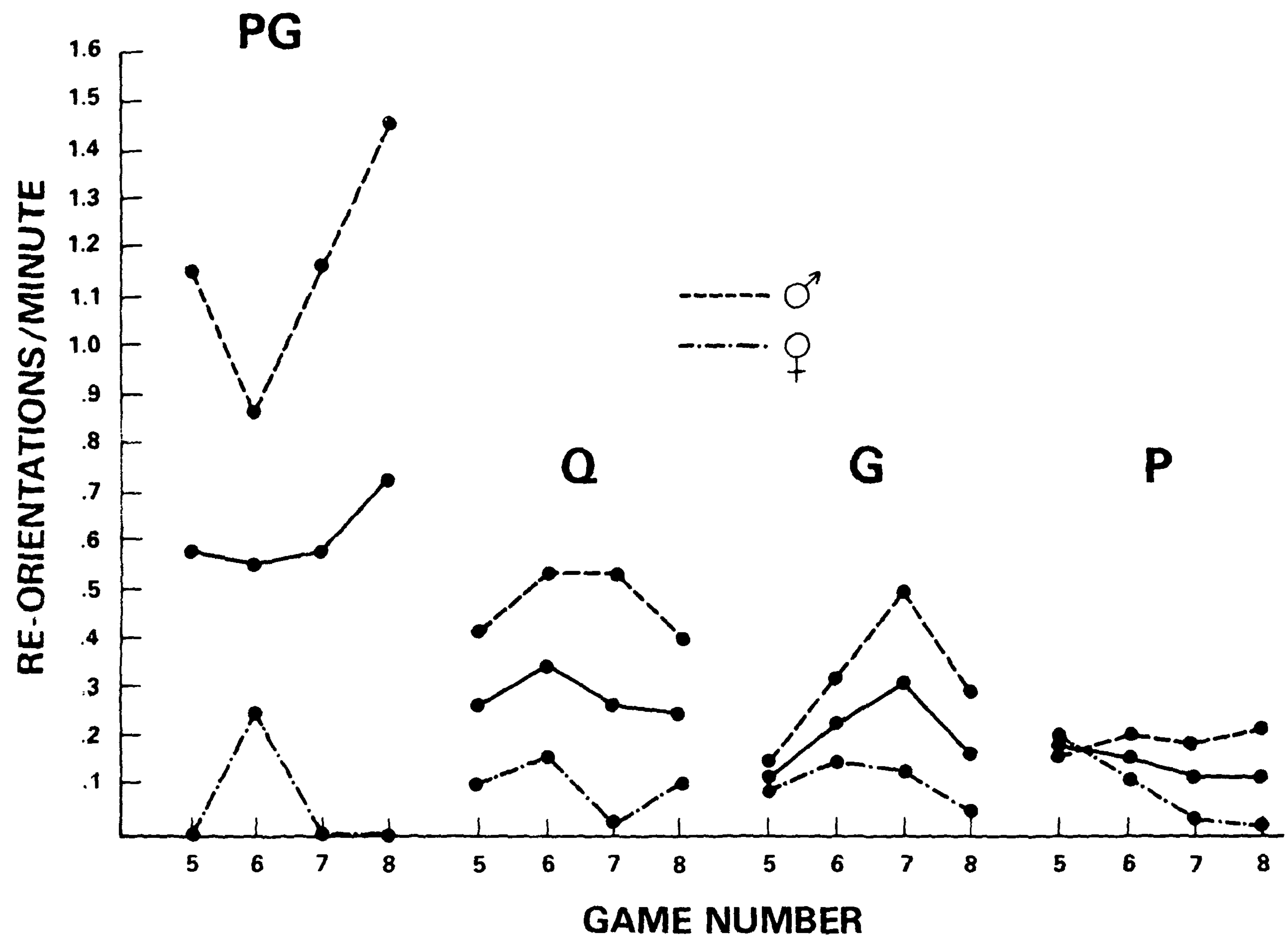


Figure 12. REORIENTATION RATE by Gender, for each Condition.

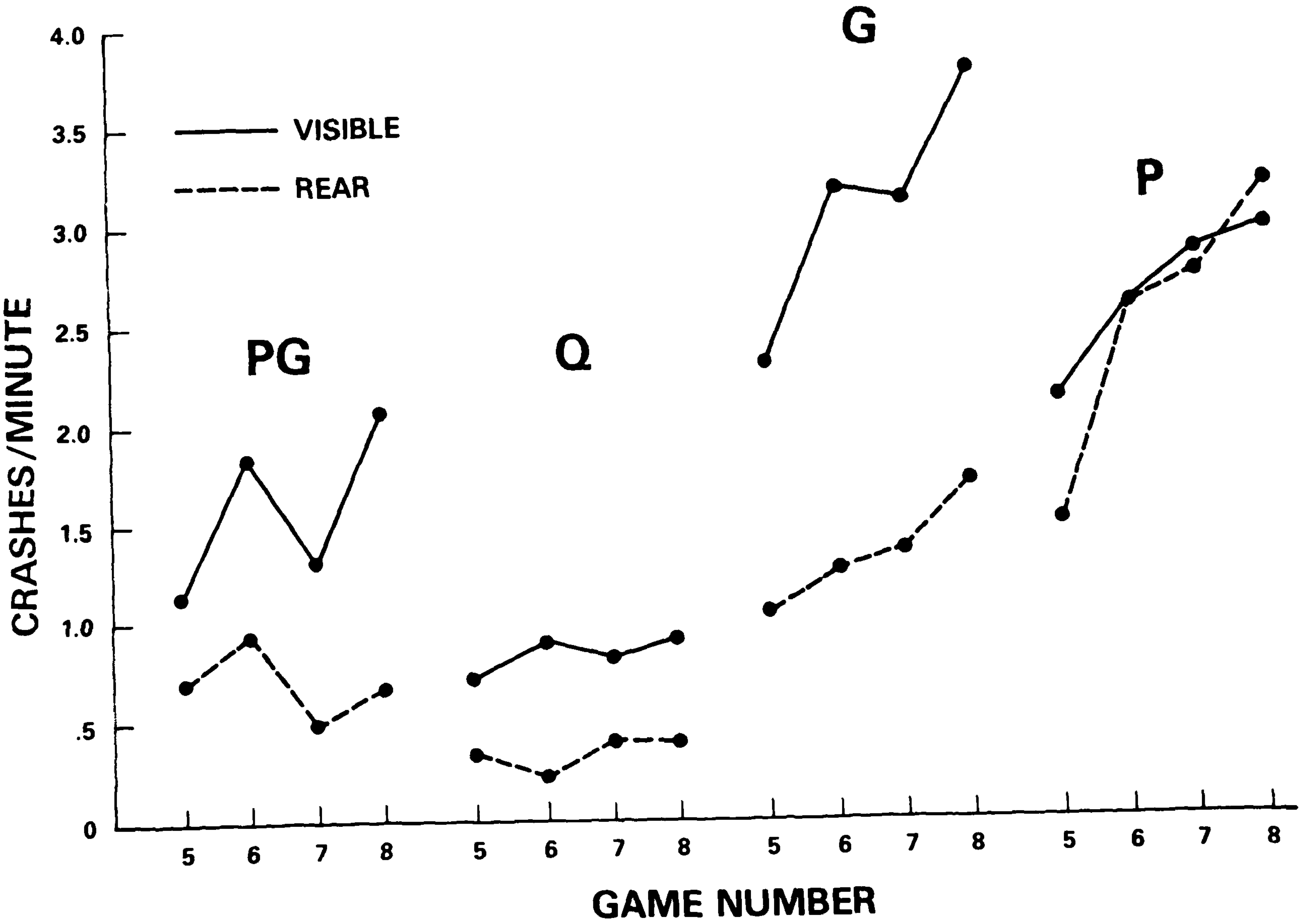


Figure 13. VISIBLE and REAR CRASH RATES for each Condition.

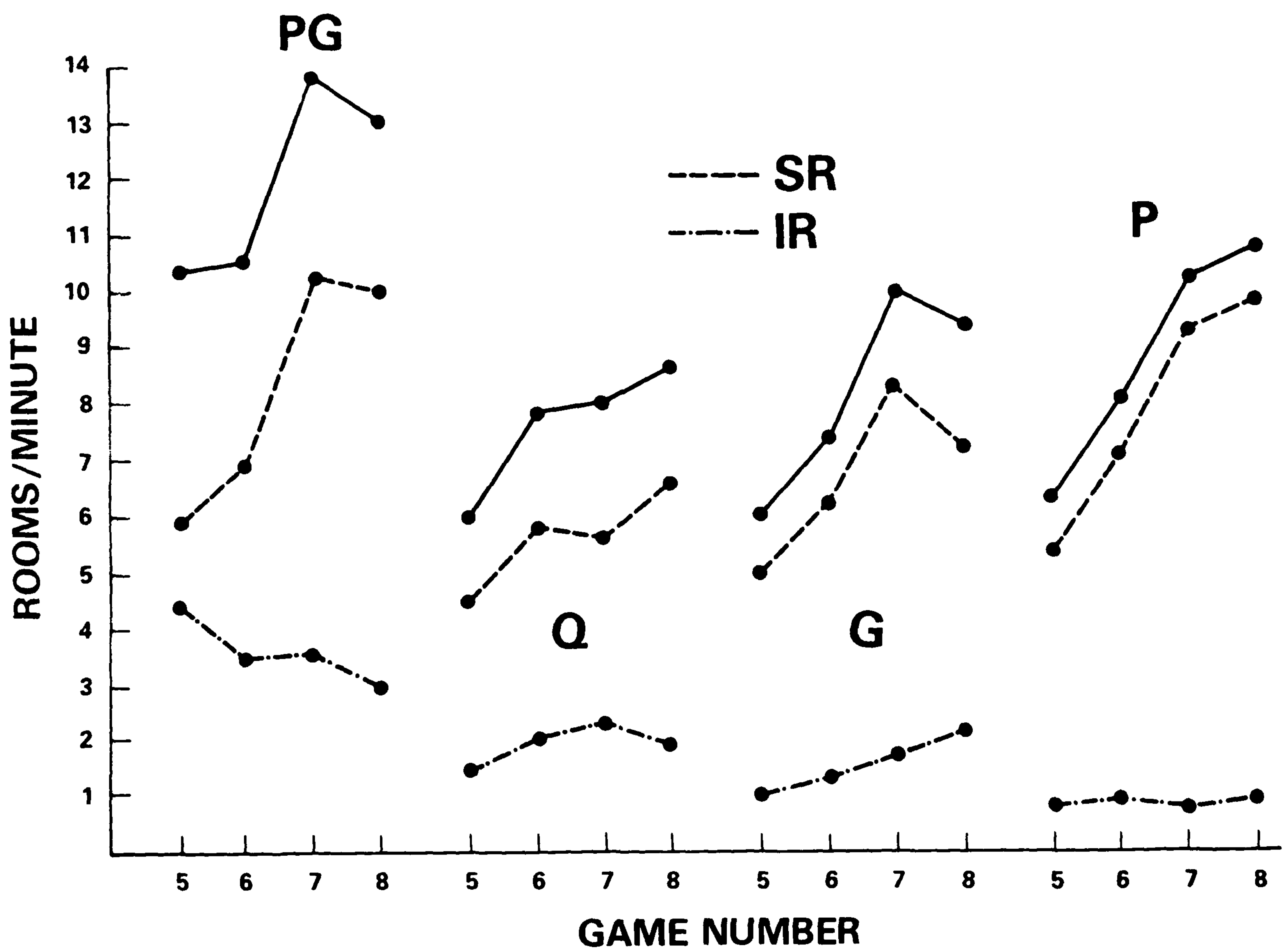


Figure 14. SURFACE RATE and INTERIOR RATE for each Condition.

suggest that, in the P condition, subjects have such a strong preference for facing north they prefer to search for the escape door on the south wall by crashing into it rather than turning around.

Figure 14 presents three "rooms per minute" functions for each INFORMATION CONDITION. These indicate the number of interior rooms (IR, bottom function), or surface rooms (SR, middle function), or total rooms (top function) occupied by the player. The top function can be interpreted as a velocity measure, since it indicates the distance (in rooms) traveled per minute. The other two show that players, particularly in the G and P conditions, have a strong preference to stay in the surface rooms. These functions should not be directly interpreted as velocity measures. Instead, they show the subject's preference for inside or outside rooms, but do not suggest that players move slower in interior rooms or faster in surface rooms. (It should be noted that 64% of the rooms in the 125 room maze are surface rooms, and 36% interior rooms.) Finally, Figure 15 shows "errors", which are any key presses that are undefined. Since the Q group had two more legitimate keys to press (to request position and goal information), it is likely that this was the reason for their increased error rate.

By looking across each figure at the functions for each INFORMATION CONDITION, it appears that different strategies are employed in different INFORMATION CONDITIONS. Rather than indicating different difficulty levels of the same game, INFORMATION CONDITIONS may be qualitatively different games, from a problem-solving perspective. That is, a task that involves finding a goal without knowledge of your own position may not have much in common with a situation where your position is known.

This interpretation is supported by results of stepwise multiple regression analyses, shown in Table 4. SCORE was predicted from the psychometric measures, shown in Table 1, for males and females separately, and for males and females combined, for each INFORMATION CONDITION. Table 4 shows the amount of variance in SCORE accounted for by the best combination of two psychometric predictors. The different INFORMATION CONDITIONS have different psychometric predictors, suggesting differences in cognitive components.

In contrast to the absence of gender differences in Table 3, data in Table 4 indicate that components of performance differ for females and males. This difference is particulary clear for condition Q. Table 4 shows that the cognitive correlates of female performance are vocabulary and reasoning, neither of which are spatial measures. Conversely, the best predictors of male performance are mental rotation and abstract orientation. Taken together with the data presented in Table 1, these results suggest that individuals may develop strategies that depend on their own skills, rather than strategies that are task dependent.

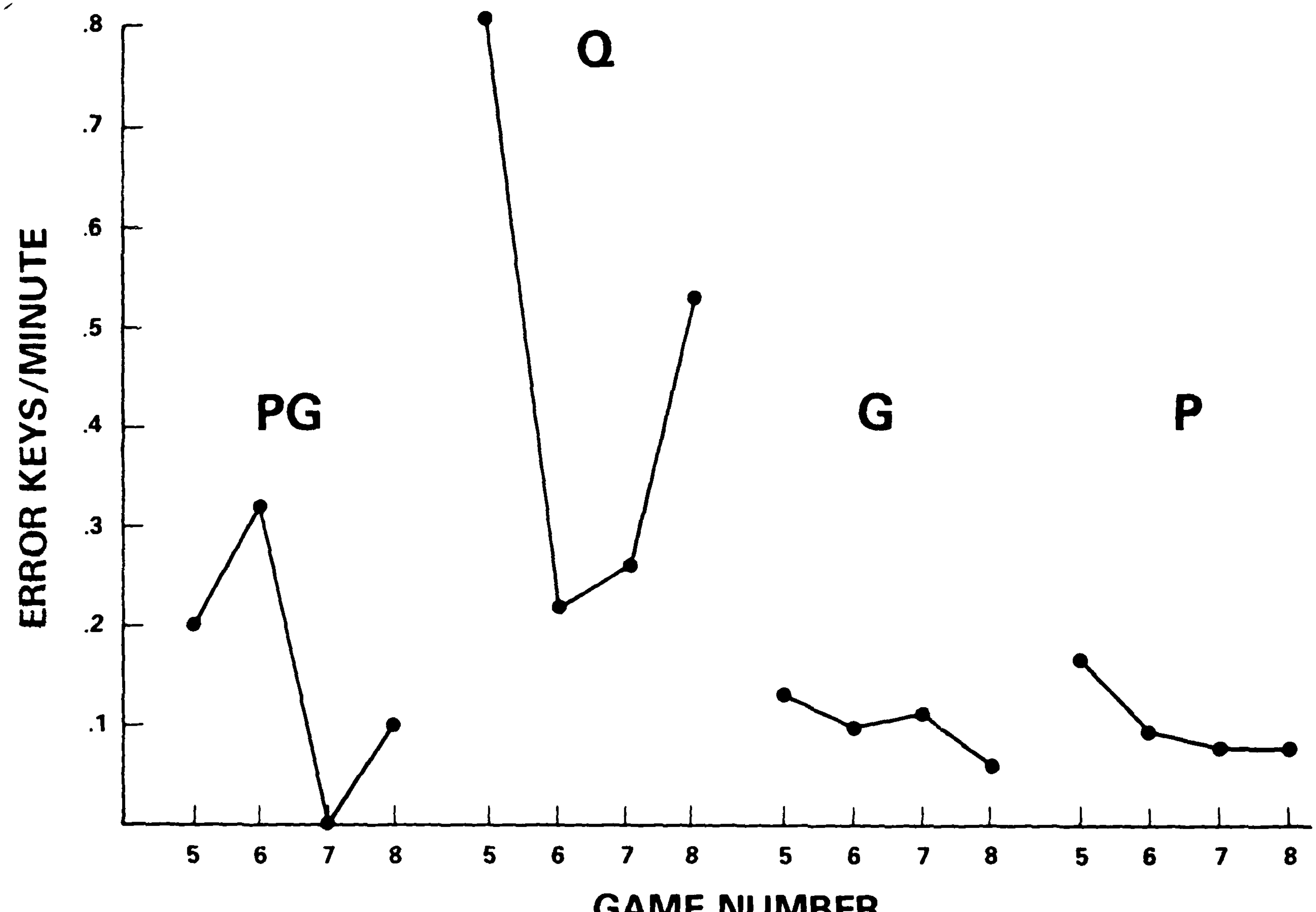


Figure 15. ERROR RATE for each Condition.

Table 4. Multiple regression analyses: predicting SCORE from psychometric measures.

INFORMATION CONDITION		Predictors	R-SQUARED
PG	females	reasoning, vocabulary	.453
	males	reasoning, abstract orientation	.556
	both	reasoning, vocabulary	.360
P	females	map & abstract orientation	.174
	males	map & abstract orientation	.320
	both	map & abstract orientation	.211
G	females	map & abstract orientation	.254
	males	map & abstract orientation	.177
	both	map orientation, reasoning	.186
Q	females	reasoning, vocabulary	.206
	males	abstract orientation, mental rotation	.409
	both	map orientation, mental rotation	.177

Summary & Conclusions

Although participants spent less than two hours playing eight games, the results show that performance stabilizes and improves quickly. If congnitive skills necessary for land navigation are also involved in game performance, this game may provide a simple, cost-effective way of exercising navigational skills. In addition, differences in INFORMATION CONDITIONS demonstrate that this variable represents different task requirements. Thus, the dependent variables selected to describe game performance seem to do so adequately, since they reflect different aspects of the players' performance and strategy.

Regression analyses indicate that the cognitive components underlying game performance are not the same for males and females. Previous research has shown that gender differences exist not only in means on spatial tasks, but also in correlations between variables for which means do not differ (Chiang & Atkinson, 1976). Further, although components underlying videogame performance differ, suggesting gender-related strategy differences, actual game performance shows little variation attributable to gender.

In sum, given that videogame skills are well retained, fun and relatively easy to acquire, they have much potential as instructional tools. In particular, games simulating navigation could be used for training spatial learning strategies. Since individuals that have different cognitive skills show similar game performance, different strategies may be employed to achieve the same results. Future instructional paradigms should provide for *flexibility in strategy* development so that learners may make the best of their individual cognitive strengths.

References

Chiang, A. & Atkinson, R. C. (1976). Individual differences and interrelationships among a select set of cognitive skills. Memory and Cognition, 6(4), 661-672.

Cohen, M. E. (1980). The effects of environmental interactions on the structure and process of cognitive mapping. Ph.D. Thesis, Temple University, Philadelphia.

Goldin, S. & Thorndyke, P. (1981). Spatial learning and reasoning skill. Santa Monica, CA: The Rand Corporation, R-2085-ARMY.

Jones, M. (1984). Videogames as psychological tests. Simulation and Gaming, 15(2), 131-157.

Kosslyn,, S. M., Brunn, J. L., Cave, C. R., & Wallach, R.W. (1983). Components of mental representations, (Contract No. N00014-79-C-0982) Arlington, Virginia: Office of Naval Research.

Pick, H. L., & Rieser, J. J. (1982). Children's cognitive mapping. In M. Potegal (Ed.), Spatial abilities: Development and physiological foundations (pp. 107-128). New York: Academic Press.

Sholl, M.J., & Egeth, H.E. (1980). Interpreting direction from graphic displays: Spatial frames of reference. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), Processing of Visible Language (Vol. 2). New York: Plenum Press.

Thorndyke, P.W., & Goldin, S.E. (1983). Spatial learning and reasoning skill. In H. L. Pick & L. P. Acredo (Eds.), Spatial orientation: Theory, research, and application (pp. 195-217). New York: Plenum Press.

Tkacz, S. (1981). What does it mean to be high spatial? Unpublished doctoral dissertation, Bowling Green State University, Bowling Green, Ohio.

Wittig, M. A., & Petersen, A. C. (Eds.). (1979). Sex-related differences in cognitive functioning. New York: Academic Press.